4th International Forum on Advanced Technologies
March 8th-9th, 2018,Tokushima, Japan

Cellular Neural Networks with Switching Two Templates by Local Features of Neighborhood

Takahisa Ando , Yoko Uwate and Yoshifumi Nishio
Tokushima University, Tokushima 770-8501, Japan
E-mail:{ando,uwate,nishio}@ee.tokushima-u.ac.jp

1. Introduction

Cellular Neural Networks (CNN) was introduced by L. O. Chua and L. Yang in 1988 [1]. The idea of CNN was inspired from the architecture of the cellular automata and Neural Network. CNN consists of analog circuit and it is capable of high-speed parallel processing. CNN has local connectivity property and its structure resembles the retina of human. Hence, CNN has been successfully used for various high-speed parallel signals processing applications such as image processing, pattern recognition and so on [2]. The performance of CNN depends on the parameters which is called the template. The template represents strength of connection between cells. If the template influences exactly, CNN can perform complex processing. In image processing of CNN, it is difficult to process complex parts of the input image; edge, background, etc. In this study, we propose a CNN method of switching two templates by using the maximum and the minimum output values surrounding the center cell. We apply the proposed method to some image processing and investigate its performance.

2. Cellular Neural Networks [1]

Basic unit circuit of CNN is called cell. The cell consists of linear element and nonlinear element. CNN contains an array in a reticular pattern of many cells. In image processing of CNN, processing is conducted by making one cell to one pixel in the image data. We show a two dimensional array composed of M × N identical cells arranged in M rows and N columns. The array of CNN and the circuit of cell are shown in Fig. 1.

A cell couples with only adjacent cells. State and output equations of cell are described as follows.

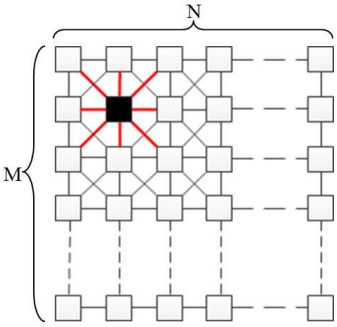


Fig.1 The structure of CNN.

State equation

$$\frac{dv_{x(ij)}}{dt} = -v_{x(ij)} + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} A_{(i,j;k,l)}v_{y(kl)}(t) + \sum_{k=i-r}^{i+r}\sum_{l=j-r}^{j+r} B_{(i,j;k,l)}v_{u(kl)}(t) + T. \quad (1)$$

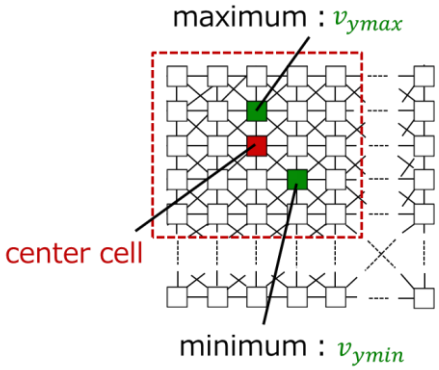
Output equation

$$v_{y(ij)}(t) = \frac{1}{2}\left(\left|v_{x(ij)}(t)+1\right| - \left|v_{x(ij)}(t) - 1\right|\right). \quad (2$$

In Eq (1), A, B and T are feedback template, feed forward template and threshold.

3. Proposed method

The feature of the proposed method is switching two templates by using the maximum and the minimum output values (v_{ymax} : cell's maximum output value, v_{ymin}: cell's minimum output value) surrounding the center cell. The concept of the proposed method is shown in Fig. 2. The algorithm of the proposed method is described as follows.



Step 1) First, decide the center cell. Then, find the v_{ymax}, and

v_{ymin} from the n × n neighborhood.

Step 2) Secondly, determine if the center cell has the maximum or the minimum output value.

Fig.2 The concept of calculation.

Step 3) In case that the center cell has the maximum or the minimum output value, center cell is applied 2nd template. In the other case, center cell is applied 1st template.

These steps are applied to all cells and repeated every 0.005 [τ].

4. Simulation result

We show simulation result of texture analysis and using templates are described as follows [3].

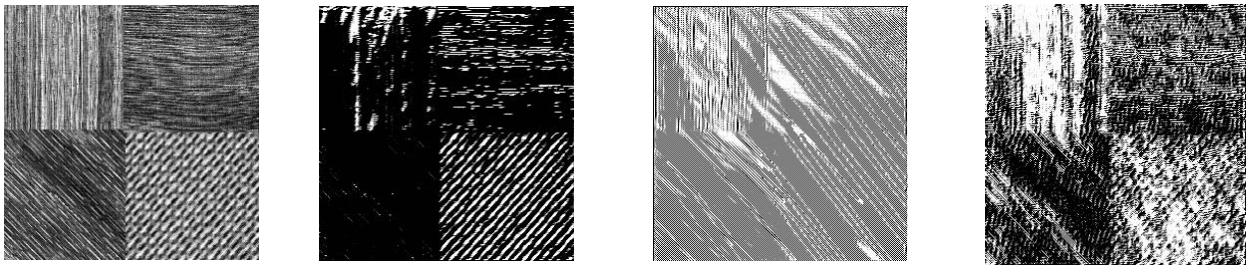
3×3 template

$$A = \begin{bmatrix} 0.86 & 0.94 & 3.75 \\ 2.11 & -2.81 & 3.75 \\ -1.33 & -2.58 & -1.02 \end{bmatrix}, B = \begin{bmatrix} 0.16 & -1.56 & 1.25 \\ -2.89 & 1.09 & -3.2 \\ 4.06 & 4.69 & 3.75 \end{bmatrix}, \ T = 1.8. \tag{3}$$

5×5 template

$$A = \begin{bmatrix} 4.21 & -1.56 & 1.56 & 3.36 & 0.62 \\ -2.89 & 4.53 & -0.23 & 3.12 & -2.89 \\ 2.65 & 2.18 & -4.68 & -3.43 & -2.81 \\ 3.98 & 1.56 & -1.17 & -3.12 & -3.2 \\ -3.75 & -2.18 & 3.28 & 2.19 & -0.62 \end{bmatrix}, \ B = \begin{bmatrix} 4.06 & -5 & 0.39 & 2.11 & -1.87 \\ 3.9 & 0.31 & -1.95 & 4.84 & -0.31 \\ 0 & -4.06 & 0.93 & -0.31 & 0.46 \\ -0.62 & -5 & 2.34 & 0.62 & -1.87 \\ 3.59 & -0.93 & 0.15 & 2.81 & -1.87 \end{bmatrix},$$

$$T = -5. \tag{4}$$



(a) Input image. (b) 3×3 template. (c) 5×5 template. (d) Proposed method (n = 7).

Fig.3 Simulation result of texture analysis.

Figure 3 shows the input image and simulation results by using only 3×3 template, only 5×5 template, the proposed method. We define that 1st template is the "3×3 Texture analysis" template and 2nd template is the "5×5 Texture analysis" template. In Fig. 3(d), the boundary of the region is clear and the texture content is characterized different. In the proposed method, two templates are applied to cells according to the features of texture content.

5. Conclusion

In this study, we have proposed a CNN method. In the proposed method, two templates are switched by using the maximum and the minimum output values containing the center cell in the neighborhood. We applied the proposed method to texture analysis. From the simulation results, the proposed method could apply two templates to each cell by the features of texture content. In the future works, we would like to investigate the performance of the proposed method for another image processing.

Acknowledgment

This work was partly supported by JSPS Grant-in-Aid for Scientific Research 16K06357.

References

[1] L. O. Chua and L. Yang, "Cellular Neural Networks: Theory," IEEE Trans. Circuits Syst., vol. 35, pp.

1257-1272, Oct. 1988.

[2] Z. H. Yang, Y. Nishio and A. Ushida,“Image processing of twolayer CNNs applications and stability,” IEICE Trans. Fundamentals, vol. E85-A, no. 9, pp. 2052-2060, 2002.

[3] L. Kek, K.Karacs and T. Roska, “Cellular Wave Computing Library(Templates, Algorithms, and Programs), Version 2.1, ” Cellular Sensory Wave Computers laboratory, Hungarian Academy of Sciencesk, Budapest, Hungary, 2007.